



Piezoelectric transformers: Control

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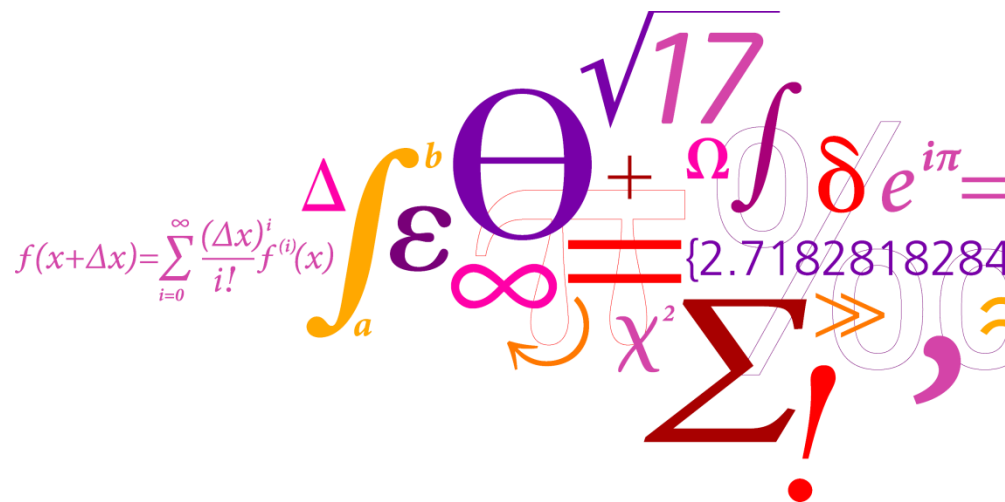
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Piezoelectric transformers: Control

Gabriel Zsurzsan, Michael A.E. Andersen, Nils Axel Andersen,
Zhe Zhang



Technical University of Denmark - DTU

DTU will develop and create
value using the natural
sciences and the technical
sciences **to benefit society.**

H.C. Ørsted, founder of DTU in 1829



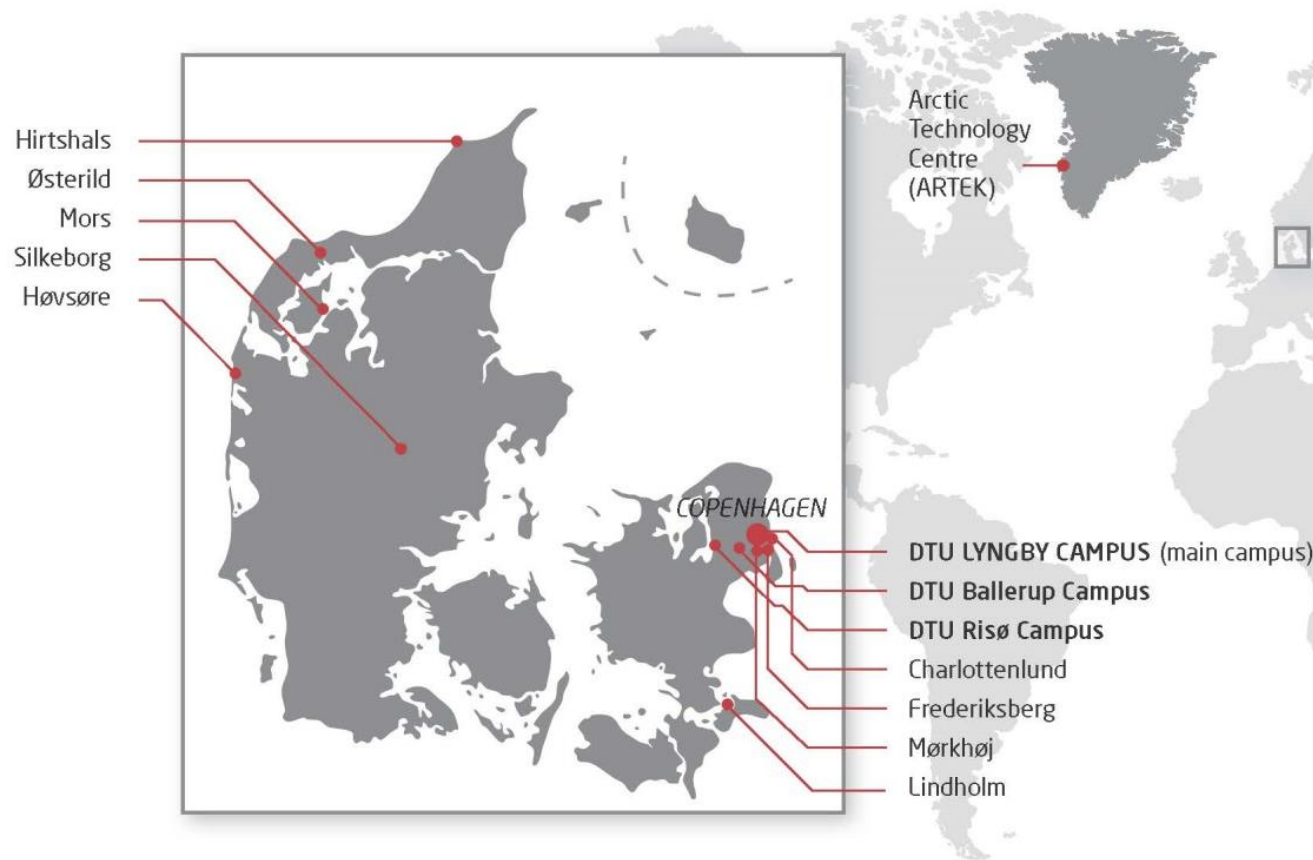
Education

Innovation

Scientific advice

Research

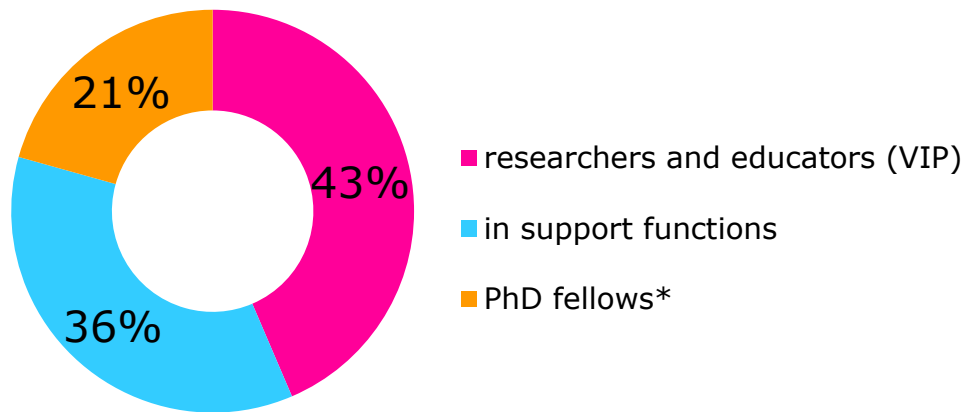
Technical University of Denmark - DTU



Technical University of Denmark - DTU

5,895

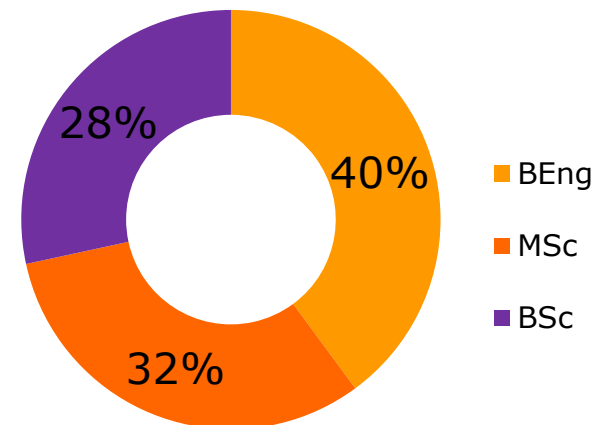
human resources (FTEs)



*Employees only

11,031

full-time students



DTU Electrical Engineering



Power engineering

Automation, control, and robotics

Biomedical engineering, CMR, ultra sound

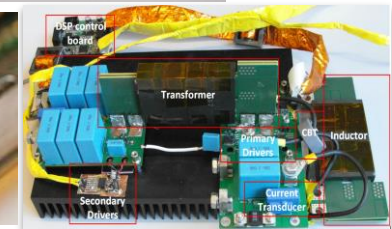
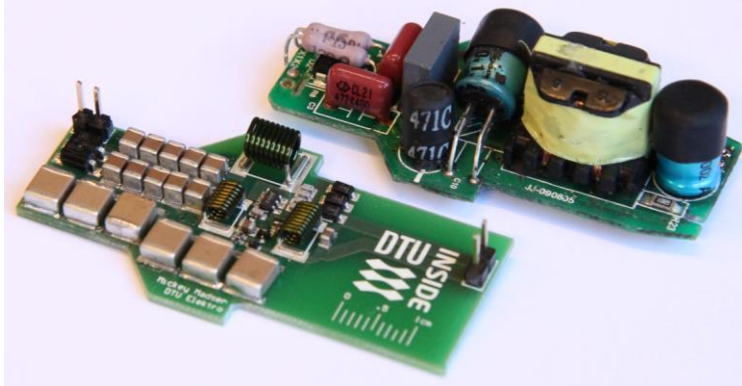
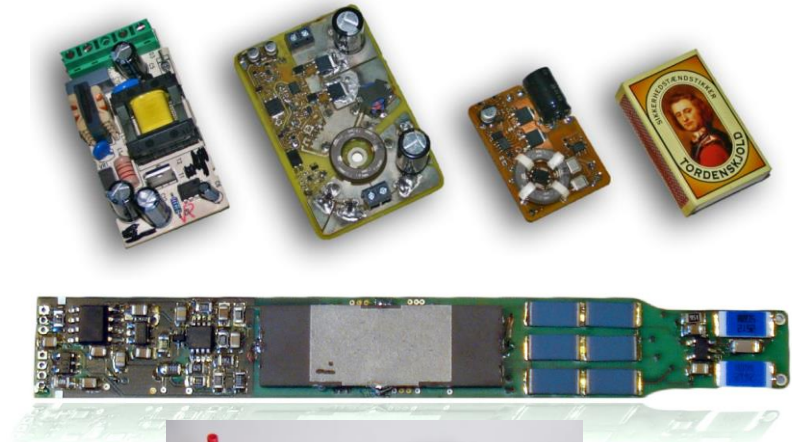
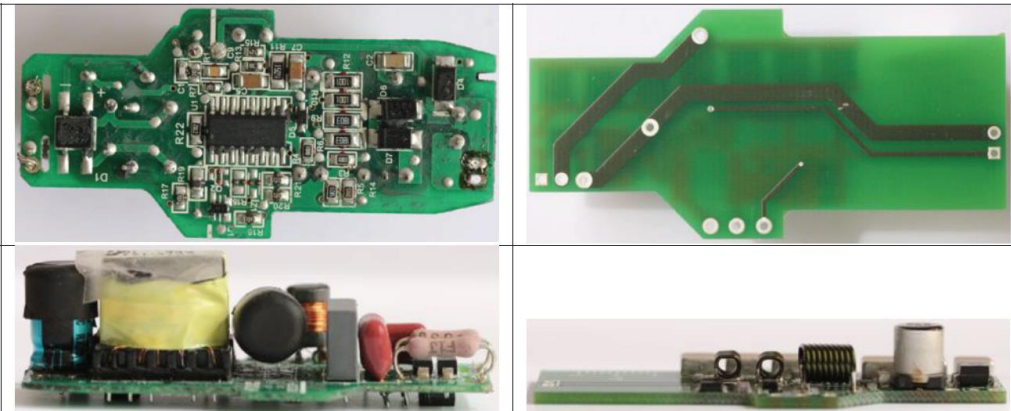
Antennas & microwave tech.

Acoustics

Hearing systems

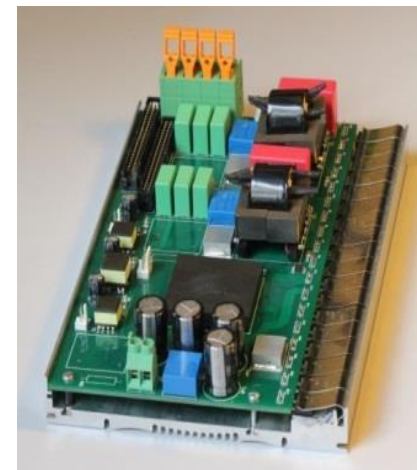
Power electronics & IC design

Electronics group



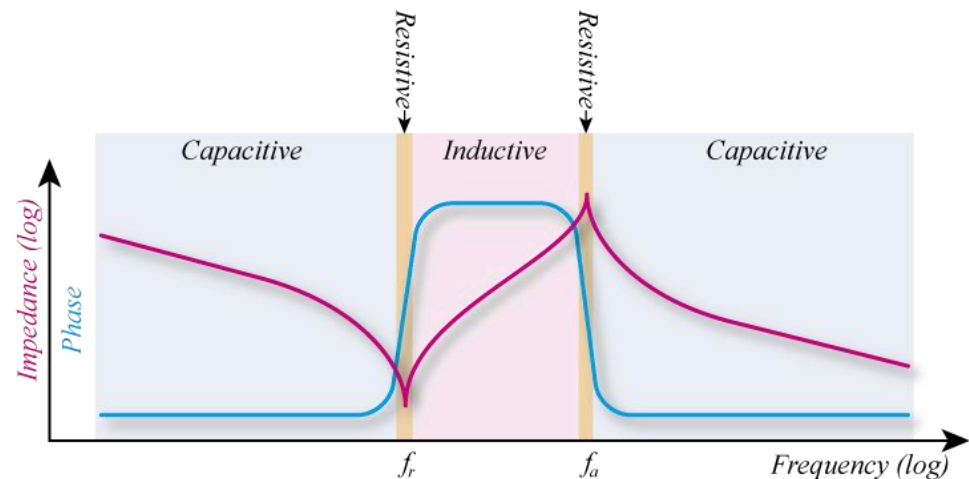
Electronics group

- Is **research leader** within:
 - Switch-mode (class D) Audio power amplifiers
 - 3 spin-off's: B&O ICEpower & TI Denmark & Merus Audio
 - Highest output power IC class-D amplifier chip ever
 - High efficiency fuel cell power converters
 - Has the **highest efficiency** (> 98%) fuel-cell power converter ever
 - VHF power converters
- Provides **unique solutions** to the collaborating companies
- One of the most **innovative groups** at DTU:
 - 46 inventions
 - Start-up companies:
 - ICEpower (former Bang & Olufsen ICEpower)
 - Texas Instruments DK (former Toccata)
 - Upcon Technology
 - Merus Audio
 - Nordic Power Converters
 - Senserna
 - Nordic Firefly



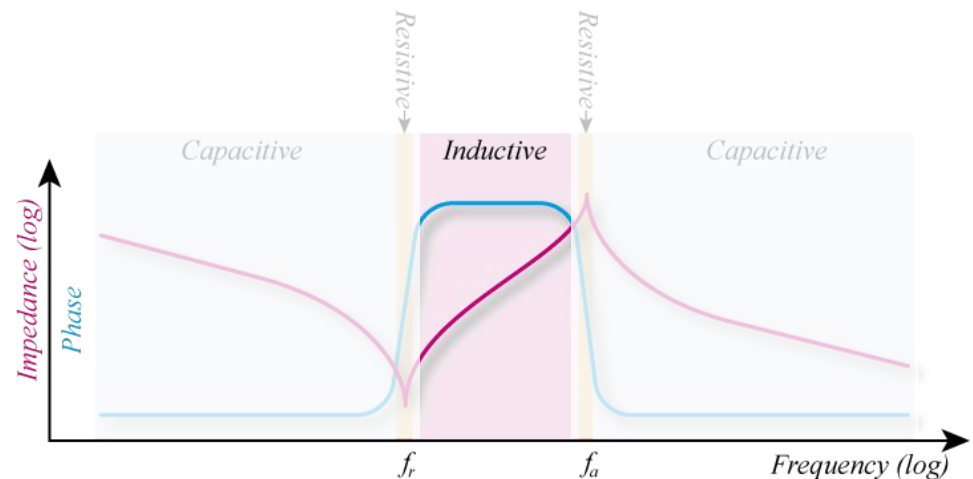
Electrical behaviour of piezos

- **Capacitive behavior**
- **Inductive behavior**
- **Resistive behavior**

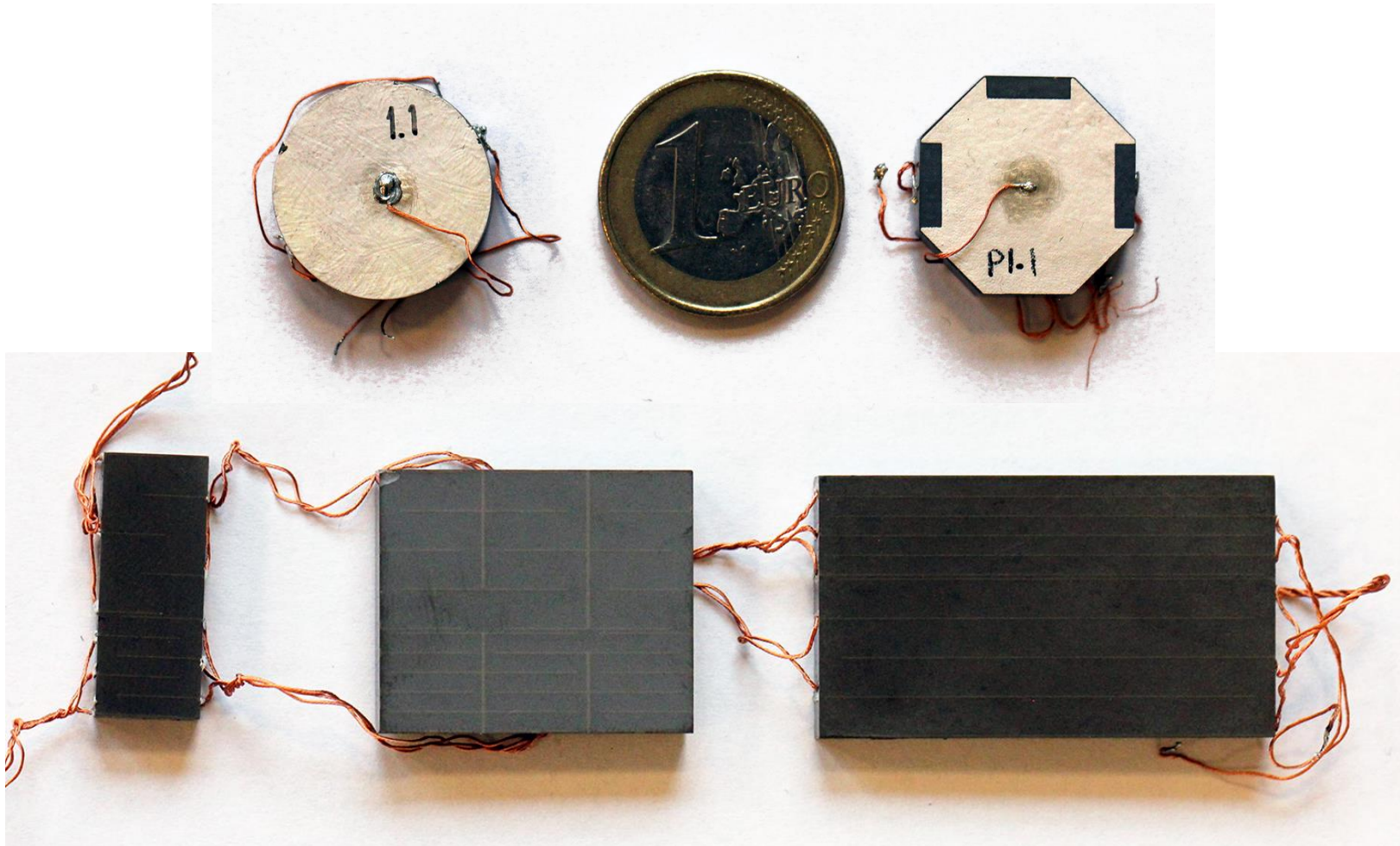


Inductive behaviour of piezos

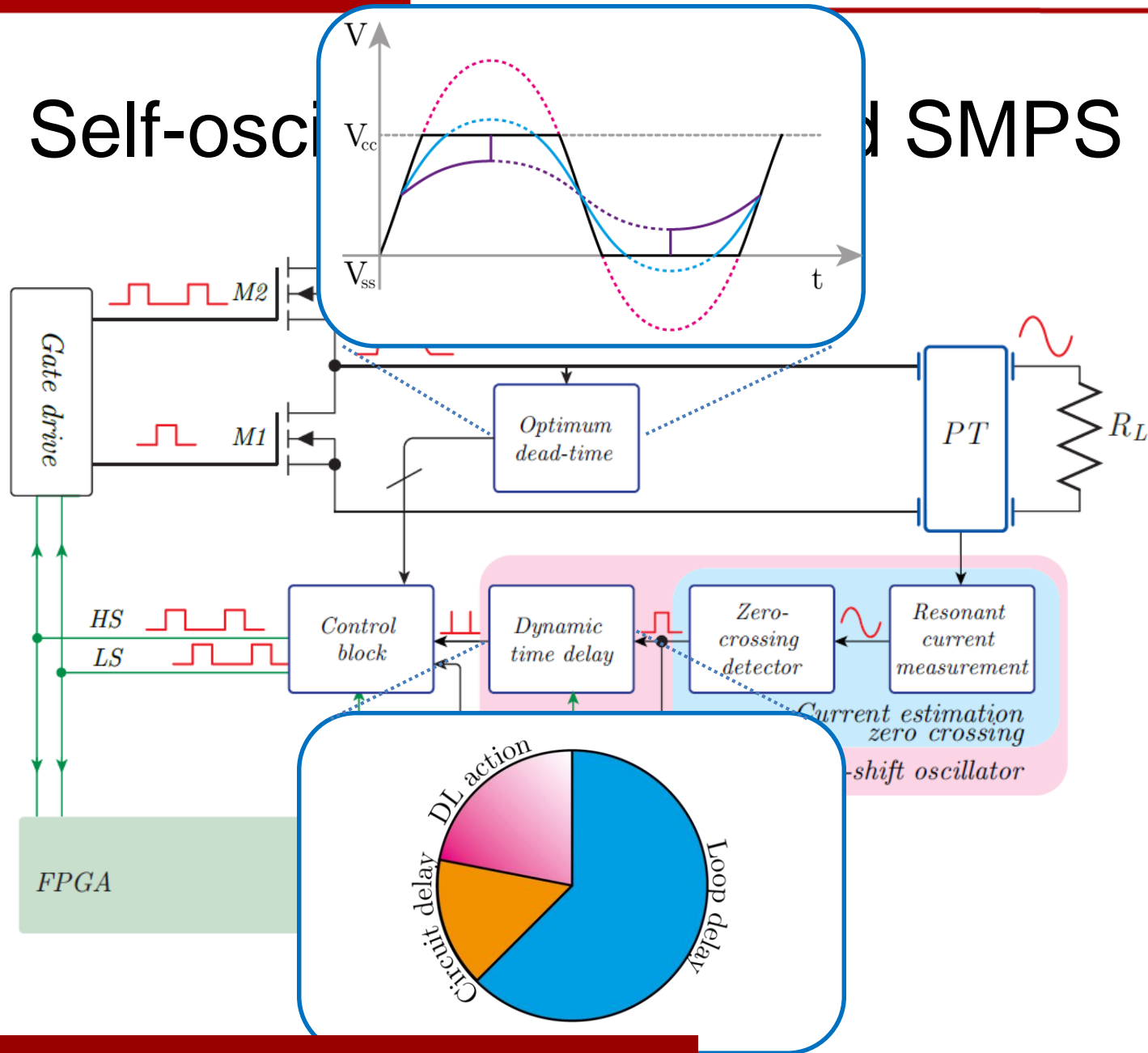
- Intro
- Capacitive behavior
- **Inductive behavior**
- Resistive behavior
- Conclusions



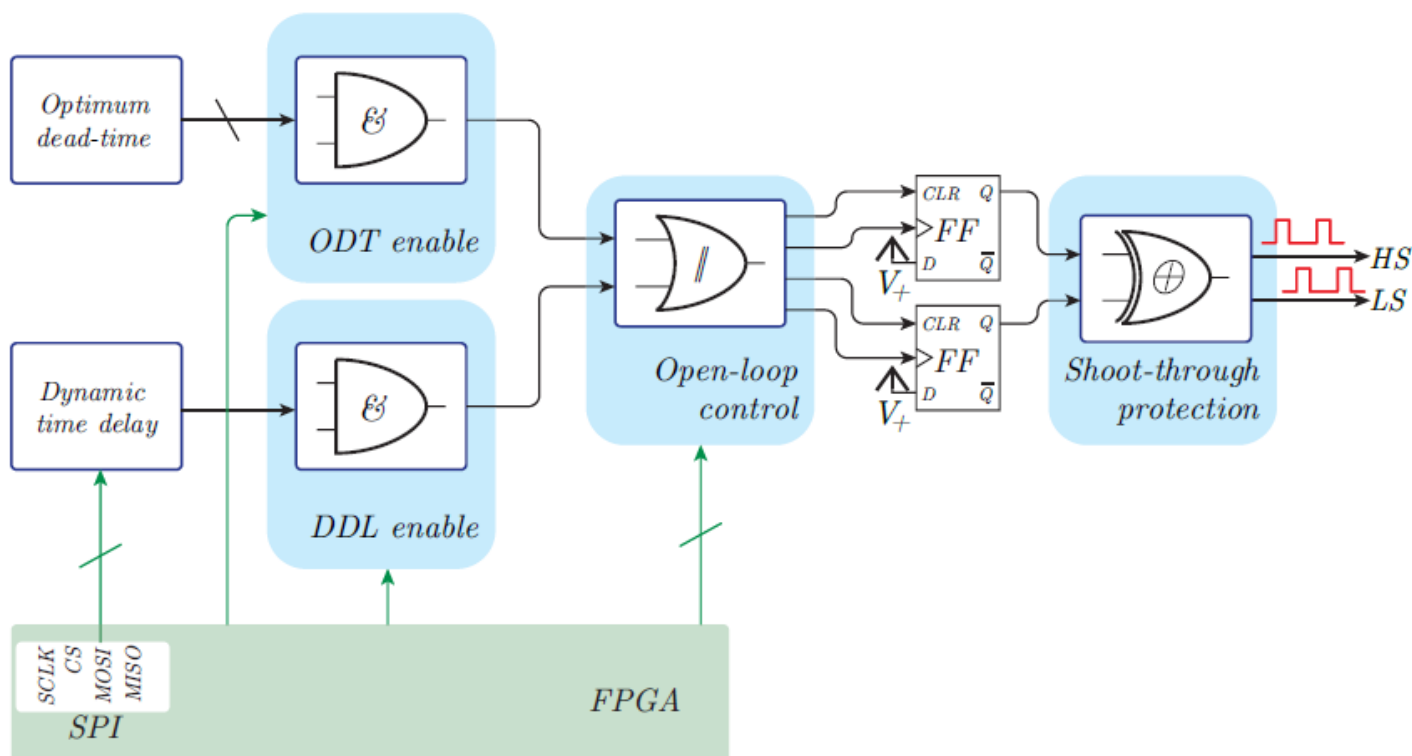
Piezoelectric transformers



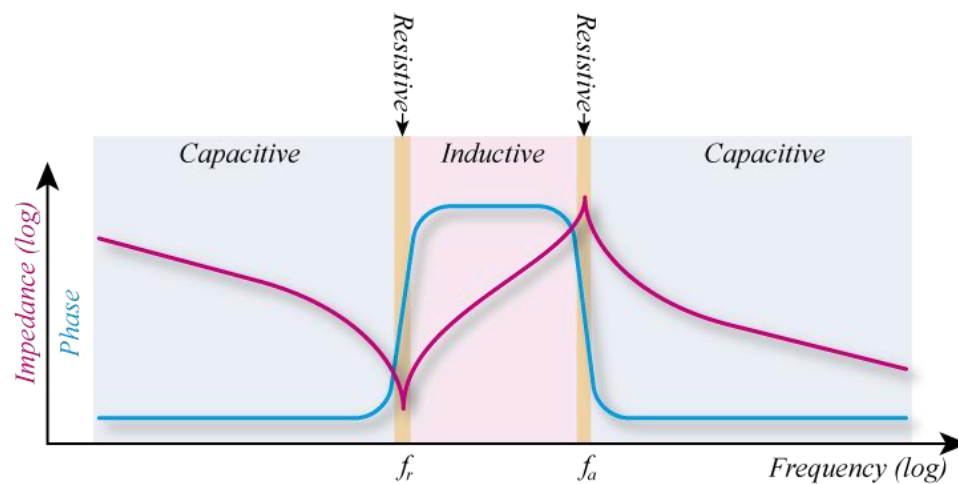
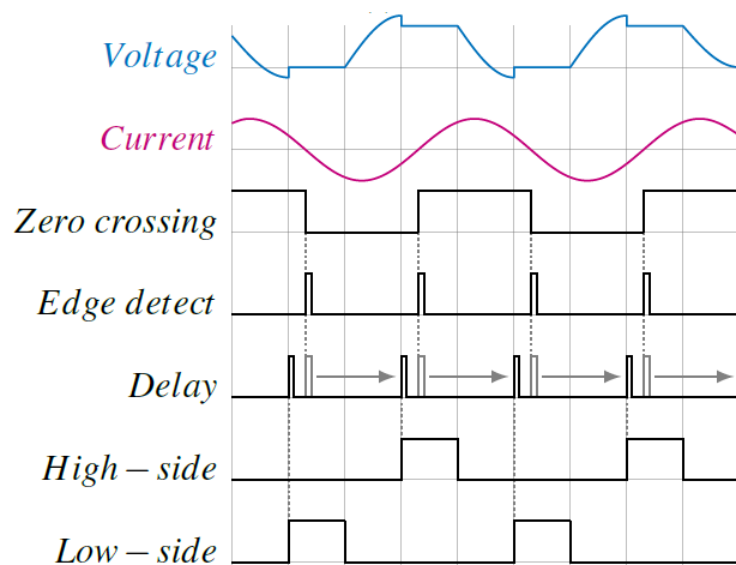
Self-oscillating SMPS



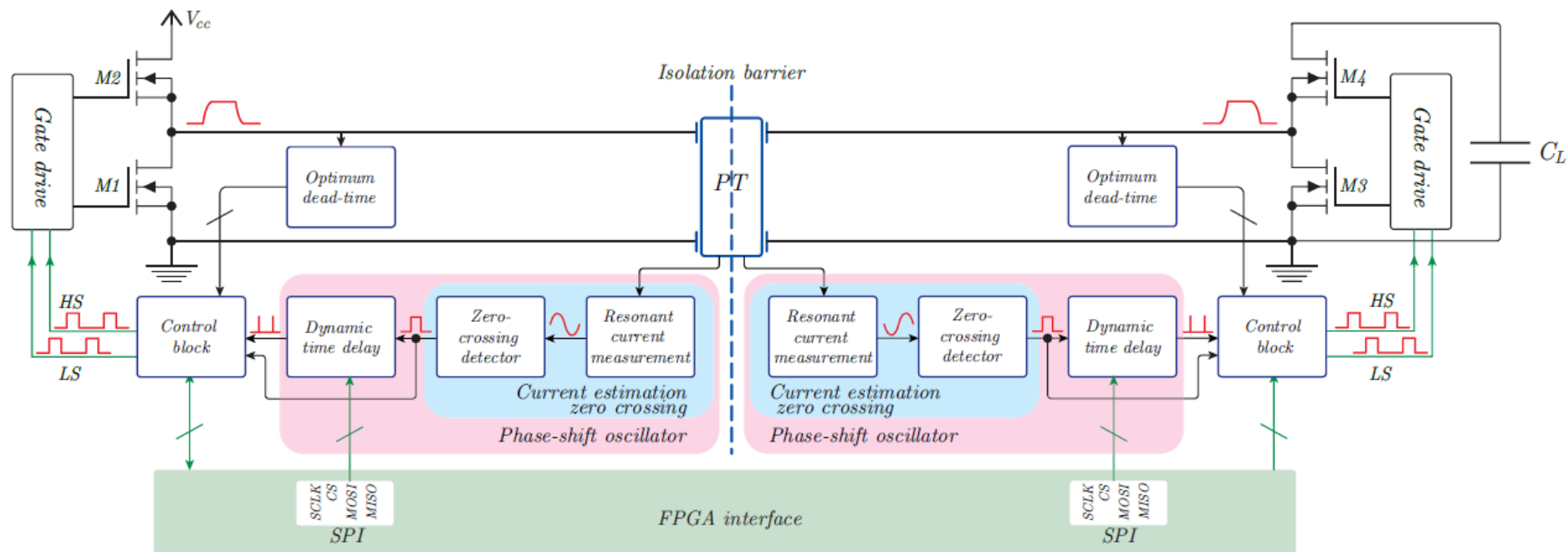
Control block



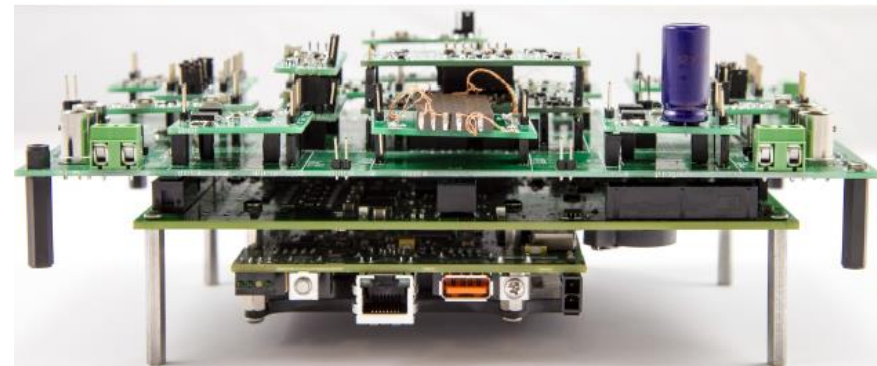
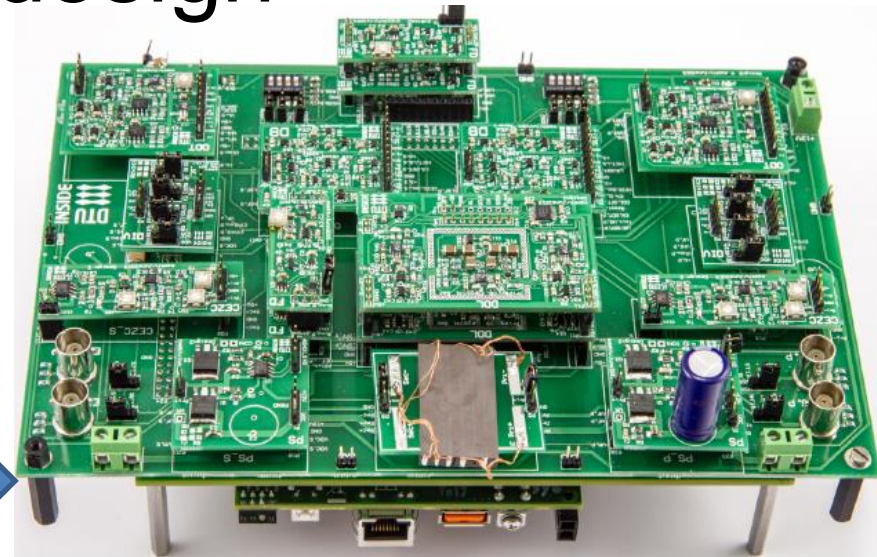
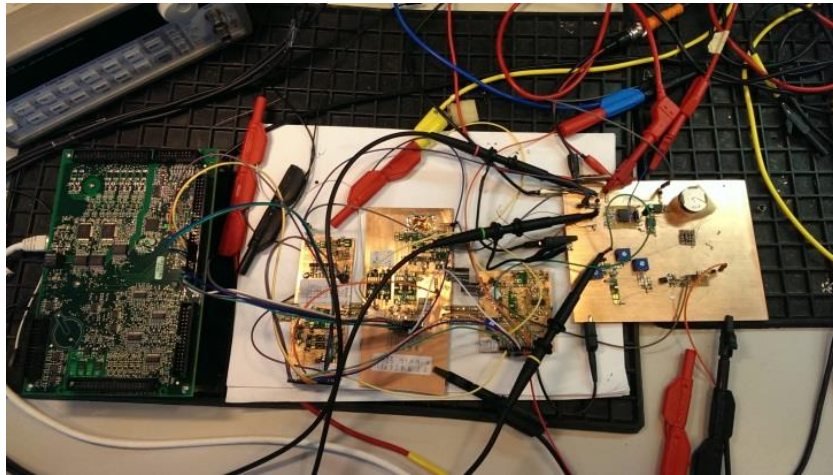
SO Principle



Bidirectional operation

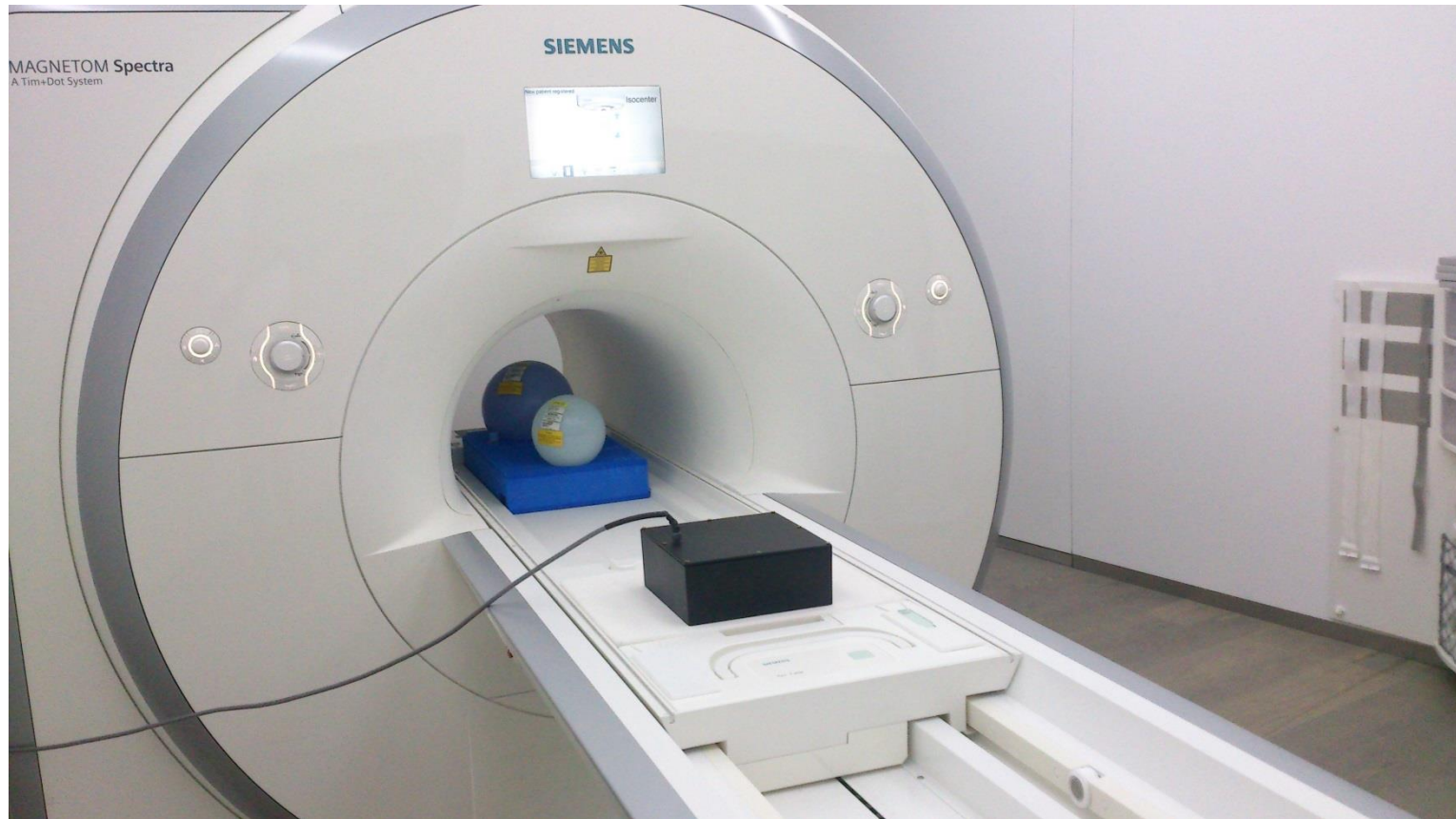


Modular design

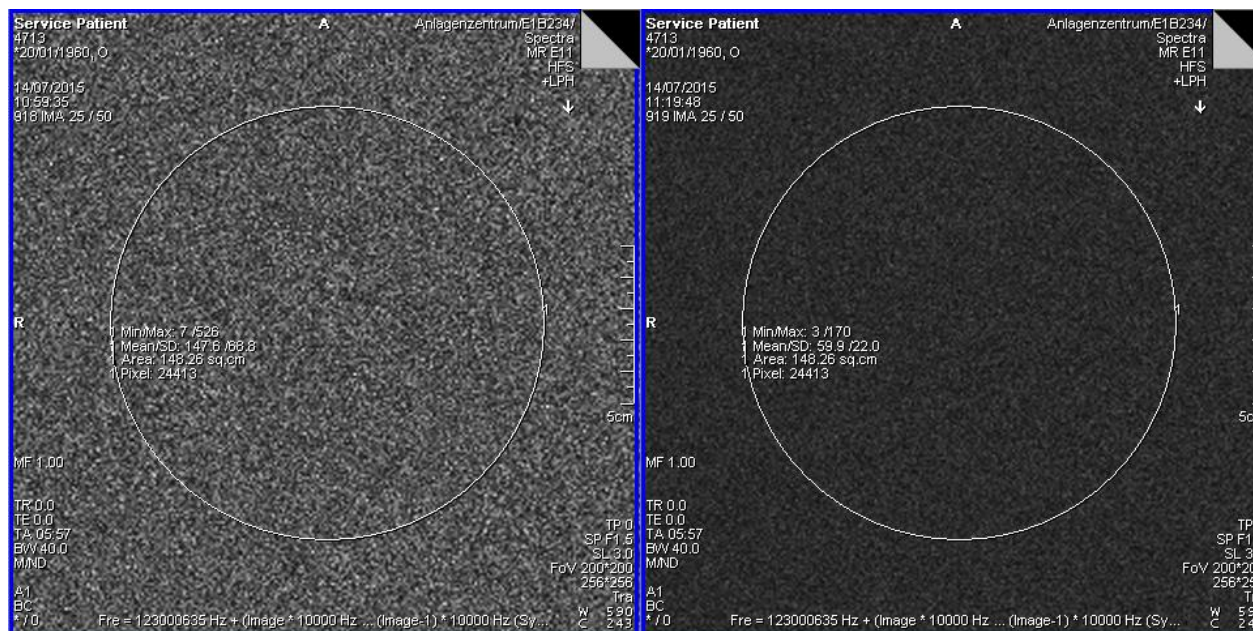


Why inductorless?

MRI testing



MRI testing

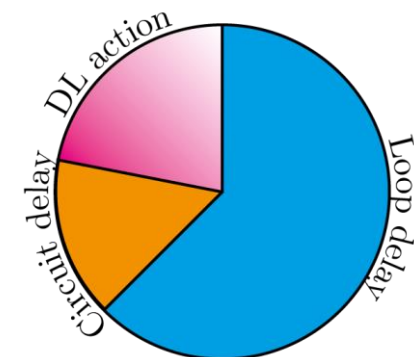
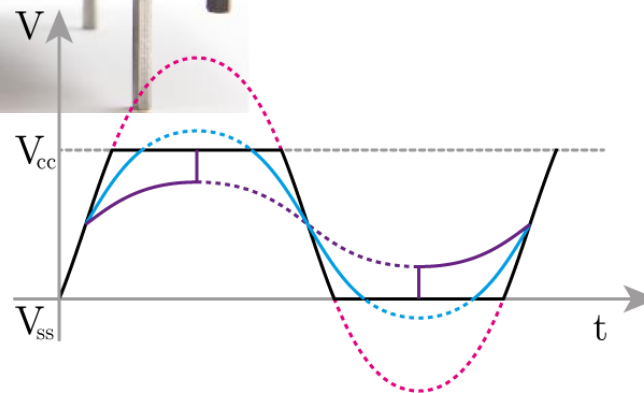
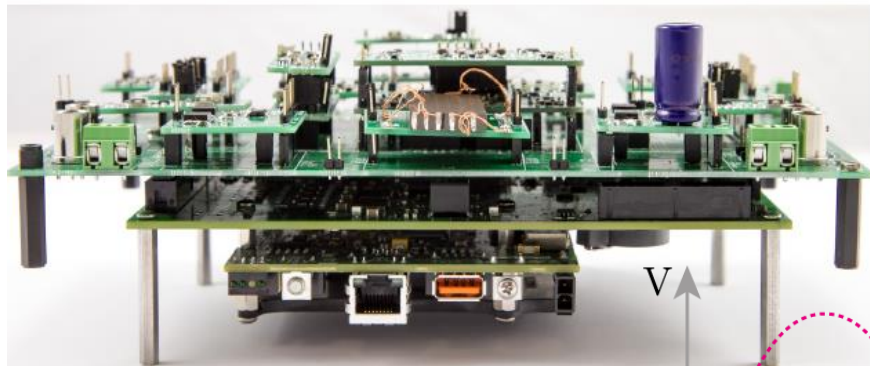


SNR degradation of 10dB

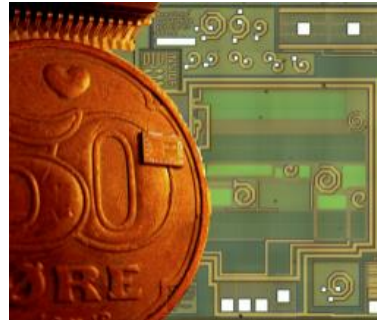
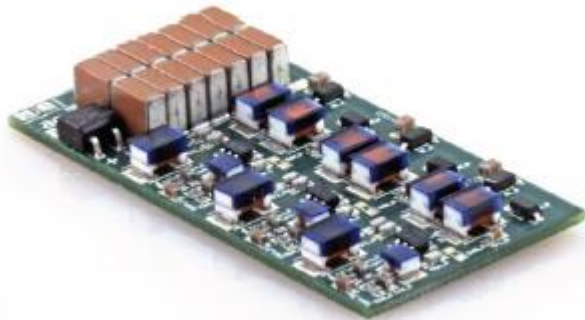
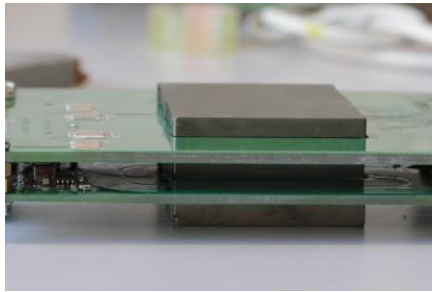
Conclusions

PT-based SMPS control method:

- Simple method for minimizing hard-switching losses
- Fast control to track and maintain self-oscillation



Thank you for your attention!



$$f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

$$\int_a^b \varepsilon \Theta + \Omega \int \delta e^{i\pi} = \{2.7182818284\}$$

$$\sqrt{17} \int \delta e^{i\pi} = \{2.7182818284\}$$

$$\chi^2 \Sigma!$$

